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SIEMENS

Socio-Technical Aspects of Long Term Embedded Systems Maintenance

Talk/Request for Comments

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Encrypted communication: GPG/PGP-ID 98356E1E, Fingerprint: 5920 9407 AB5C 8B28 3C7B 4F02 F16F 2523 9835 6E1E.

Technical

- Structured programming
- Appropriate languages
- Proper (idiomatic) use of libraries
- …

Process

- Code reviews (formal/informal)
- Inspections and walkthroughs,
- Use of SW engineering tools (VCS, issue tracking, CI, …)
- …

Alan Perlis on sugar consumption

When someone says »I want a programming language in which I need only say what I wish done,« give him a lollipop.

- Excellent MPEG decoders in Fortran
- Horrible QM simulations in Java

Conway's »Law«

»*Any organisation that designs a system (defined broadly) will produce a design whose structure is a copy of the organisation's communication structure.*«

Socio-Technical Congruence and Long-Term Maintenance

- Create awareness for LTM issues (i.e., pick right patches)
- Influence »decision makers« (i.e., label important fixes)
- Extract »shared project knowledge« (implicit processes)

Examples from (Commercial) Industry

- Predict bugs from organisational structure
- Successful approach!
- Requires a-priori knowledge of organisation

- Predict build issues from organisational structure
- Succesful approach!
- Requires special data collection infrastructure

Consequences

- Social factors ☞ software quality
- Unix reference manual does not cover humans ☞ sociology required

Examples from (Commercial) Industry

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- Unix reference manual does not cover humans ☞ sociology required
- Quantitative, of course

Pharmaceuticals

- ✓ A-priori understanding (to some extent)
- ✓ Tests & statistics

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Software

- ✗ Comparative experiments
- ✗ Quantify people and behaviour
- ✗ Personal experience limited

Codeface

Goals

- *Automatically* determine collaboration structure from development artefacts
- Include temporal *dynamics*

Approach

- Find relationships between developers
- Infer and verify communities
- Find structural properties of communities

History

- Initially: Research project at Siemens Corporate Technology
- International academic cooperation
- Open source (mainly GPLv2)

Data source

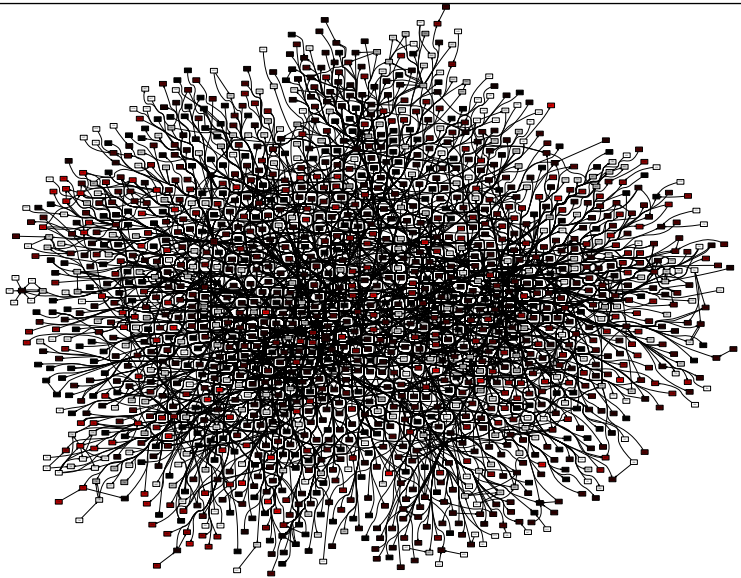
```
commit 1bb22891a9609b235f8e43d0315d566f65197ef9   <- Unique identifier of the commit
Author: Mitchell Joblin <joblin@mail.com>         <- Author of change
Date:   April 15 13:22:10 2014 +0200              <- Authorship date
Committer: Wolfgang Mauerer <mauerer@mail.com>    <- Committer of change
Date:   May 1 23:54:18 2014 +0200                 <- Commit date
```

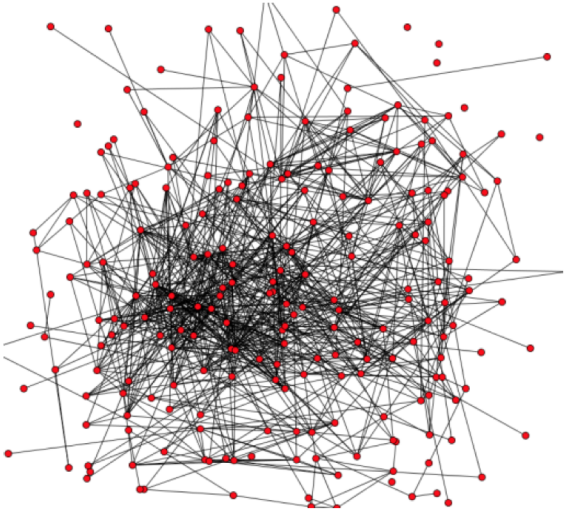
```
    Abort cluster analysis when matrix off diagonal sum is zero…   <- Description of changes made

    Signed-off-by: Mitchell Joblin <joblin@mail.com>               <- Acknowledgement of authorship
    Reviewed-by: Wolfgang Mauerer mauerer@mail.com                 <- Acknowledgement of review
```

```
diff --git a/codeface/R/cluster/persons.r b/codeface/R/cluster/persons.r   <- File affected by the changes
@@ -1001,8 +1001,14 @@ performAnalysis <- function(outdir, conf) {
  conf) {
   if (length(colnames(id.subsys)) == 2) {
     id.subsys <- NULL
   }
-
-  if(sum(adjMatrix) == 0) {                                   <- Changed lines
+
```

Network construction

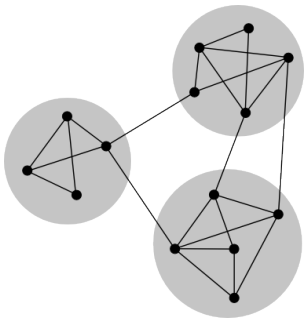
- Tagging (“Signed-off-by”)
- Committer/author
- Overlapping code contributions
- Feature co-changes





Goal: Partitioning into subgraphs

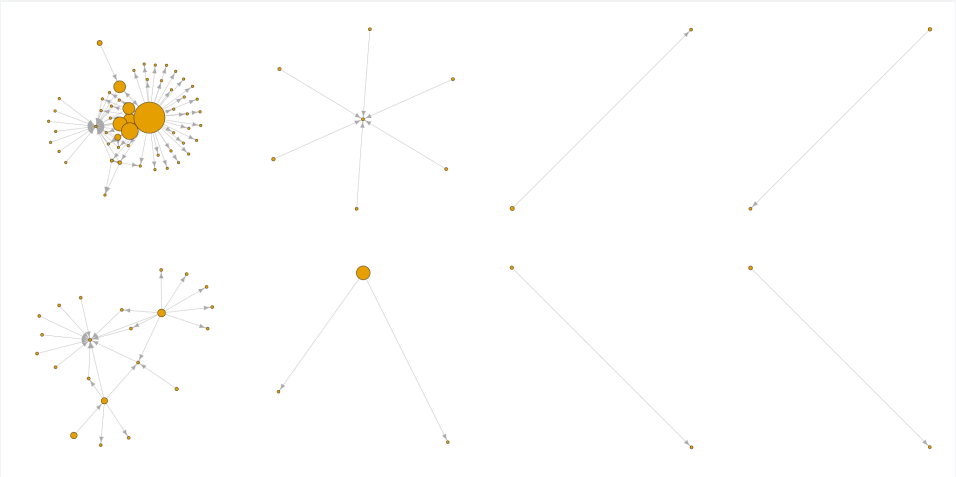
- Strongly connected internally
- Weakly connected externally



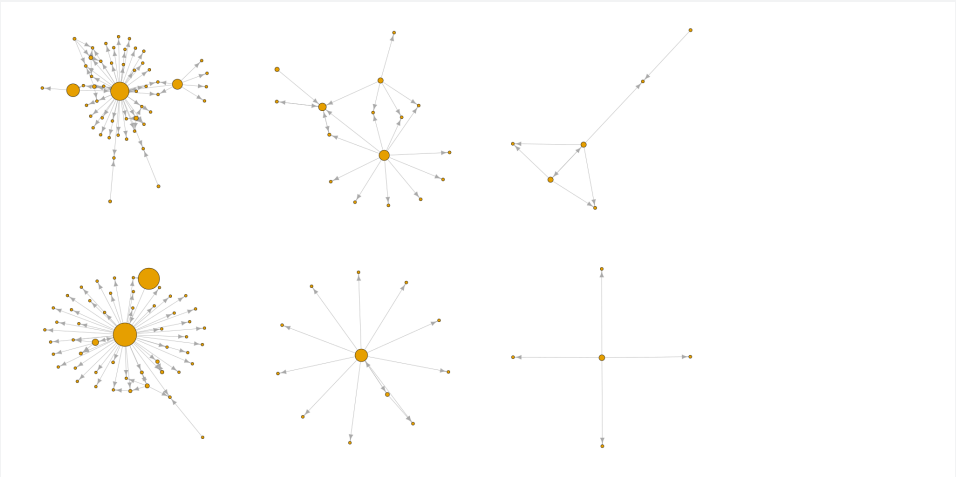
Validation

- Statistical methods
- Sociological verification

Qemu 0.11.0 (Sep 2009) Virtualisation/Machine Emulation

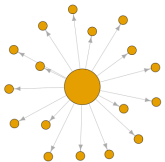


Qemu 0.13.0 (Oct 2010) — Virtualisation/Machine Emulation

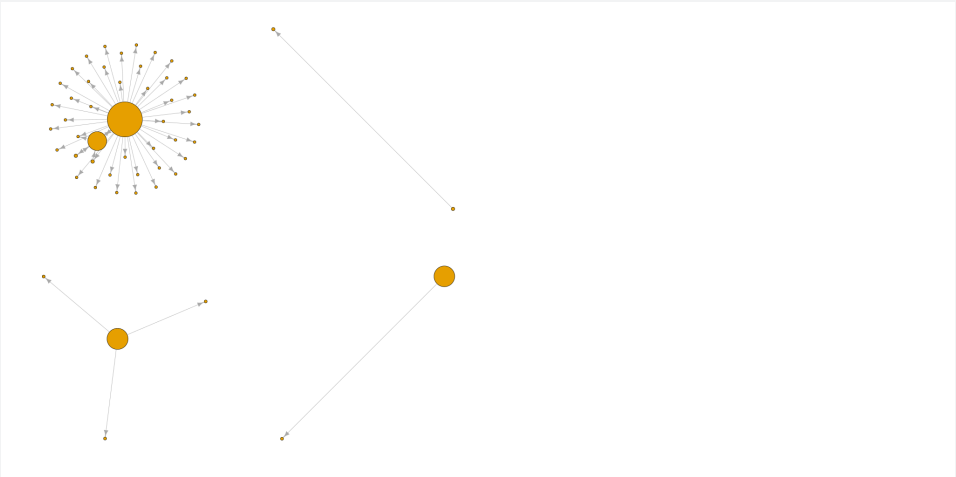


Qemu 1.5.0 (May 2013) — Virtualisation/Machine Emulation

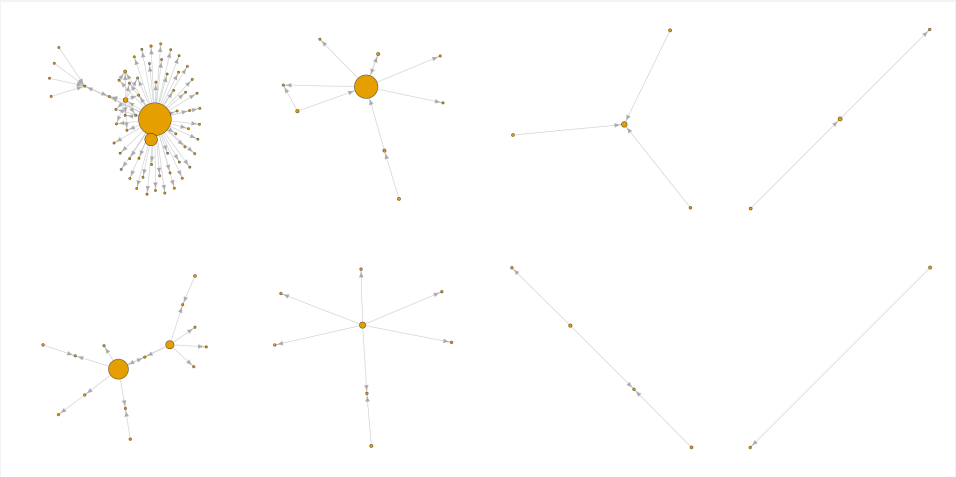
Git 1.1.0 (Jan 2006) — Revision Control System



Git 1.3.0 (Apr 2006) — Revision Control System



Git 1.8.3 (May 2013) — Revision Control System



Quality Estimation

- Meaningful community structures vs. random properties
- Randomise clusters
  - Rewire edges
  - Keep properties (e.g., "amount" of participation)
- H_0: Clustering stems from unorganised, random process.
- Reject $\rightarrow$ Decomposition makes sense
- Then: Large-scale sociological verification (surveys)

Quality Estimation

- We did the maths
- We asked people

Alternative Industrial Approach

Ken Schwaber says: A team has seven people (plus or minus two). Full stop!

How's that relevant?

- Coordination structure vs. non-functional requirements
  - Are there long-term reliable structures?
  - Which persons?
- Handling team dynamics
  - Knowledge loss (i.e., will anyone fix my problem in 7 years?)
  - Knowledge distribution

Can't beat manual knowledge

- Yes, you may know that for project $\langle x \rangle$
- But how about $\langle Y \rangle$, $\langle Z \rangle$, $\langle \zeta \rangle$, $\langle \Omega \rangle$, …?

Random

- Randomly (iid) distributed edges (connections)
- Erdős-Rényi model: »typical« nodes (developers) .
- Hub nodes: extremely rare

Scale free

- No »typical« nodes (developers)
- Hub nodes: frequent
- Large real-world networks (biology, sociologie, internet routers, …)
- Robust against *random* changes

Random

- Distributed system knowledge ✓
- Bad scalability ☞ burn out individuals ✗

Long-Term Implications

- Easy to find experts on anything
- Limited overall complexity
- Bad technical subsystem isolation

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Scale free

- Maintainer: Architectural (structural) knowledge ✓
- Hub dev hit by proton beam ☞ structural problems ✗

Long-Term Implications

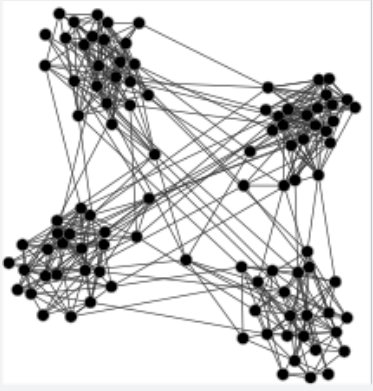
- Support or friction can come from maintainers
- Sudden disruption

Hierarchical

- Developers: hierarchical layers
- Command and control

Modular

- Developers form strongly connected communities
- Low coupling, high cohesion



Hierarchical

- Enforce policies ✓
- Flexibility ✗

Long-Term Implications

- Easy to establish favourable processes
- Support or friction can come from upper hierarchy levels

Modular

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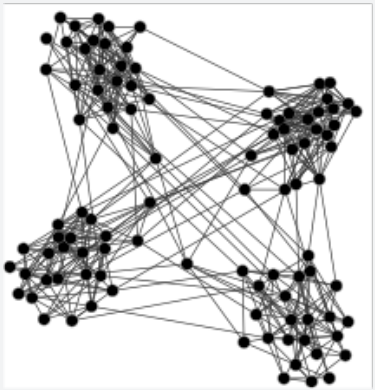


Hierarchical

- Enforce policies ✓
- Flexibility ✗

Modular

- Focus on deeply specialised issues ✓
- Friction at boundaries ✗

Long-Term Implications

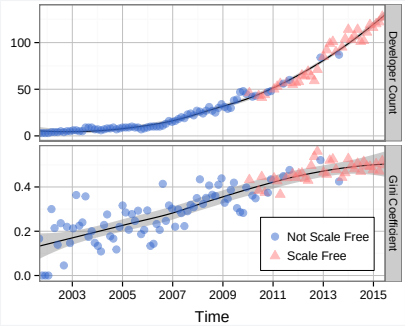
- Easy to establish favourable processes
- Support or friction can come from upper hierarchy levels

Long-Term Implications

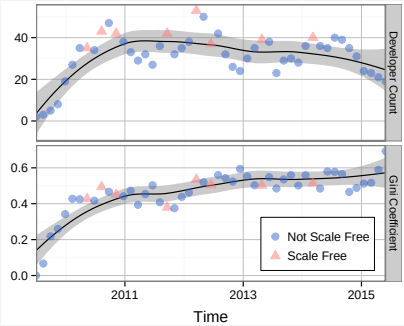
- Maintain specific portions long-term
- Little interference from unrelated code

Image source: strategic.mit.edu

LLVM (typical)



Node.js (untypical)



Three typical phases

1. High coordination equality, slow growth, hierarchical structure
2. Superlinear growth of developer count, transition to scale freedom
3. Stabilisation of scale freedom — hierarchy (core dev), heterarchy (peripheral devs)

Implications on long-term maintenance

- Establishing structured processes should be done in phase 1 or 3
- Focus LT support efforts differently depending on project phase
- Speeding up transition from 1 to 3

Identifying Key Persons

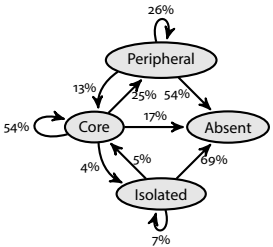
- Official project structure: maintainers, sub-maintainers, …
- *Unofficial* social order: Who's effectively in charge?
  - Yes, you may know that for project ⟨x⟩
  - But how about ⟨Y⟩, ⟨Z⟩, ⟨ζ⟩, ⟨ξ⟩, …?

Developer Classification

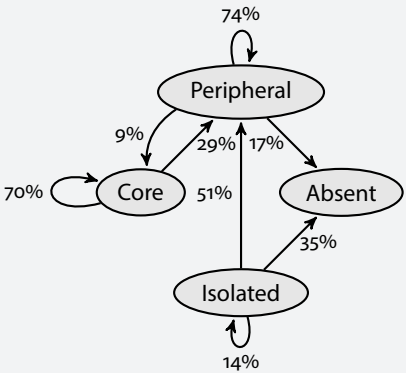
Core	Developer with connectivity in 80% quantile
Peripheral	Non-Core-Developer with connectivity > 0
Isolated	Developer with connectivity $= 0$
Absent	Developer without commits

Markov Chain

- Transition graphs: MaxLike
- Window size: 3 months (quasi stationary)



Chromium



Observations

- Strong transfer from core to peripheral
- Good integration of isolated developers
- High loss rate (isolated to absent)

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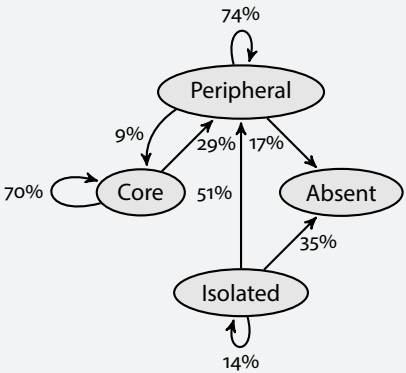
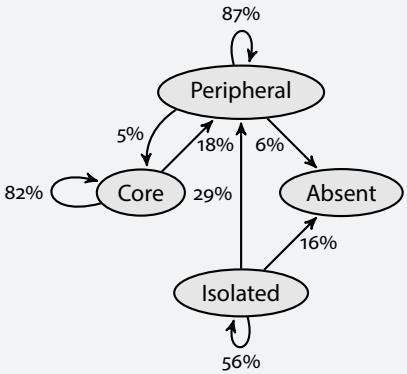


Observations

- Strong transfer from core to peripheral
  ☞*Intermittent efforts? Lack of commitment?*
- Good integration of isolated developers
  ☞*Implicit review. Chance to »label«/classify patches regarding back-porting etc.*
- High loss rate (isolated to absent)
  ☞*Loss of know-how + responsibilities, bit rot (+ watch out for NSA!).*

GCC



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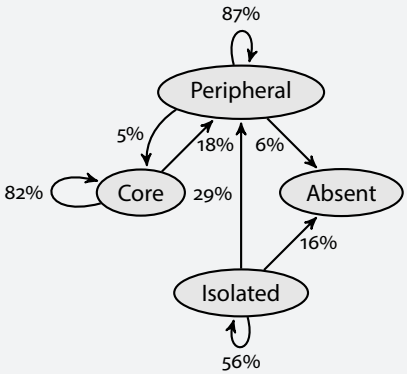
- Very stable set of core developers
- Stagnation of peripheral and isolated developers

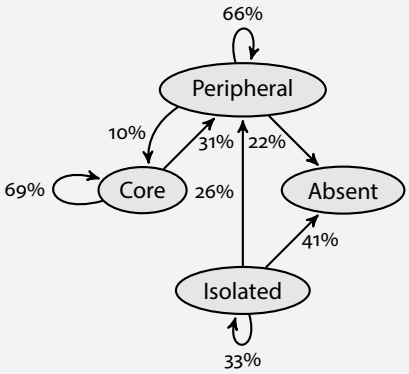
GCC



Observations

- Very stable set of core developers
  ☞*Established expert code basis; long-term planning possible*
- Stagnation of peripheral and isolated developers
  ☞*Potential review bottleneck, uncoordinated structural changes, backport issues*

MongoDB



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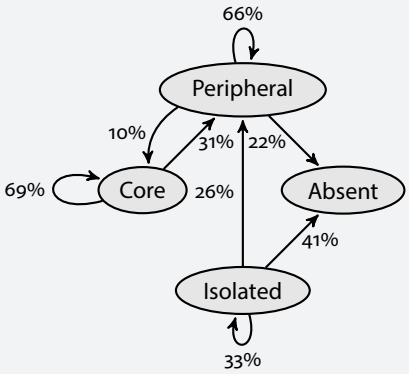

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- High loss of peripheral and isolated developers
  ☞*One time contributions, easily miss important LT fixes!*
- Bad integration of isolated developers
  ☞*Loss of know-how, bit rot (+ watch out for NSA!). Easily miss important LT fixes!*

Questions? Questions!

- Code: `https://github.com/siemens/codeface`
- Homepage: `https://siemens.github.io/codeface`

- M. Joblin, S. Apel, C. Hunsen, WM, *Classifying Developers into Core and Peripheral: An Empirical Study on Count and Network Metrics*, Foundations of Software Engineering (submitted), 2016
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- WM, M. Jäger: *Open source engineering processes*, IT special issue 55, 2013